DOCUMENT RESUME

ED 265 845 IR 011 969

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TITLE Interaction of Learner Control and Prior Conceptual Understanding in Computer-Assisted Video Instruction.
PUB DATE Apr 85
NOTE 33p.; Paper presented at the Annual Meeting of the American Educational Research Association (Chicago, IL, March 31-April 4, 1985).
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS Analysis of Variance; Aptitude Treatment Interaction; Biology; *Computer Assisted Instruction; Concept Formation; Epistemology; Higher Education; Hypothesis Testing; *Individual Differences; *Individualized Instruction; Intermode Differences; Science Instruction; Tables (Data); *Time Factors (Learning); *Video Equipment; Videotex
IDENTIFIERS *Instructional Effectiveness; *Learner Control

ABSTRACT

The purpose of this study was to examine how learners with different levels of prior understanding of a topic interact and learn from computer-assisted video instruction systems when they have control of content, sequence, pace, and mode of instruction. Based on pretest scores, 80 subjects were randomly selected, half with low prior conceptual understanding, and half with high prior conceptual understanding. Half of the subjects from each group were randomly assigned to a program vs. learner control treatment which consisted of computer-assisted video instruction modules on protein synthesis. A 2X2 analysis of variance was conducted on posttest scores and time on task, followed by a regression analysis to assess the relationship of other independent variables with posttest scores and time on task. In the learner control condition, subjects with high prior conceptual understanding in the subject area made significantly better use of control options and their time than did subjects with low prior conceptual understanding. In the program control condition, there were no significant posttest score differences, but there were significant time on task differences between subjects with low prior conceptual understanding and high prior conceptual understanding. Low prior conceptual understanding subjects had significantly higher posttest scores in the program control condition than in the learner control condition; however, there were no significant differences in time on tasks between conditions. Finally, high prior conceptual understanding subjects performed equally well in both program control and learner control conditions. A three-page list of references and several tables/figures complete the document. (Author/JB)

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ED265845

INTERACTION OF LEARNER CONTROL AND PRIOR CONCEPTUAL UNDERSTANDING IN COMPUTER-ASSISTED VIDEO INSTRUCTION

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Paper presented at the American Education Research Association Annual Meeting in Chicago, Illinois, April, 1985.

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INTERACTION OF LEARNER CONTROL AND PRIOR CONCEPTUAL UNDERSTANDING
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ABSTRACT

It is commonly assumed that individual differences in abilities and aptitudes will be accomodated if learners have more control over pace, amount of practice, or style of instruction they receive. The purpose of this experiment was to examine the question of how much control should be given to individuals with varying degrees of prior conceptual understanding within the context of computer-assisted video instruction. Based on pretest scores, 80 subjects were randomly selected, half with low prior conceptual understanding and half with high prior conceptual understanding of the subject matter. Half of the subjects from each group were randomly assigned to a program vs. learner control treatment comprised of computer-assisted video instructional modules on protein synthesis. A 2 X 2 analysis of variance was conducted on posttest scores and time on task followed by a regression analysis to assess the relationship of other independent variables with posttest scores and time on task. As expected, in the Learner Control condition, subjects with high prior conceptual understanding in the subject area made significantly better use of control options (sequencing of material, review, remediation, depth of study, and amount of practice) and their time than did subjects with low prior conceptual understanding. In the Program Control condition, there were no significant posttest score differences, but there were significant time on task differences between low prior conceptual understanding and high prior conceptual

understanding subjects. Low prior conceptual understanding students had significantly higher posttest scores in the Program Control condition than in the Learner Control condition. However, there were no significant differences in time on task between conditions. Finally, high prior conceptual understanding subjects performed equally well in both Program Control and Learner Control conditions. However, they were significantly more efficient in their use of time in the Learner Control condition.

One of the newest forms of computer-assisted instruction is the "intelligent" videodisc, which is a technology that combines the logical and device-control powers of the microcomputer with the quality and quantity of image storage provided by a laser-read videodisc player. The growing use of videodisc technology for image storage represents a significant technological advance whose impact is just beginning to be realized. Bork (1981) stated that some of the major features of the "intelligent" videodisc are random access to a variety of information (video images, audio sequences, variable speed display, graphics, animation, etc.) and a high degree of learner interaction. The video component can add visual and audio presentation to interactive microcomputer components such as learner control, review, record keeping, branching, and immediate feedback. Furthermore, intelligent video systems provide an unprecedented opportunity to develop new ways of representing information, including multimedia schemes that would mix different representational forms in whatever ways are most conducive to learning.

Surprisingly little is known about how to determine whether a particular representation of a concept, principle, or body of knowledge is better or worse than another for conveying information to the learner. How do various representational modes such as computer text, graphics, video images, and audio affect the thinking of people who use them? In particular, what are the effects of these media attributes on learning? It is assumed that "the technology of a medium affects the modes of interactions with the users and the transmitted content affects the knowledge acquired" (Salomon, 1979 p. 8). Despite the importance of the topic of media's effect on cognition, little is known about how various attributes of computer- assisted video instruction, such as control, amount of practice, feedback and other variables, affect learning outcomes.

The purpose of this study was to examine how learners with different prior understanding of a topic interact and learn from computer assisted video instruction systems when they have control of content, sequence, pace, and mode of instruction. This is an important issue because the video provides vast information resources of an entirely different kind from those provided by the computer. As the amount of information increases, so also does the number of ways in which it can be put together and accessed by learners. The ways in which users access information and make decisions about which information to retrieve may affect their ability to assimilate, retain, and use it later on.

One of the key attributes of a computer-based learning system is the amount of control that can be given to individual learners. It is often assumed that learners will benefit if given more control over the pace, sequence, depth of study, or style of instruction they receive (Bruner, 1962). There is some evidence that giving learners increased control of their own learning will help them develop "the capacity for independent regulation of their own mental processes and behavior" (Landa, 1976, p.8). Furthermore, other research studies have shown that feelings of self-efficacy and self-determination , and the skills involved in taking independent responsibility are enhanced by control (Bruner, 1966; Lawler, 1982; Papert, 1980). Many assertions have been made that the learner controlled method can accomodate individual differences in initial aptitude (Bunderson, 1980; Grubb, 1967; Hartley et al., 1969; Merrill, 1979). However, the empircal results from studies in learner control research have been contradictory (Judd, 1972; Steinberg, 1977). In most studies, students actually learned less when they had control over their own sequencing and instructional strategies (Judd, 1972). In a study by Olivier (1971), the student group having the capability for self-selection of materials did significantly worse than program-controlled (computer controlled sequencing, remediation, and amount and depth of study) counterparts. In fact, the few studies which have found positive

advantages for learner control have involved highly motivated and/or intelligent subjects who might be expected to do better under less structured conditions (Fry, 1972; Judd, 1975; Seidel, 1975; Tennyson & Rothen, 1979).

Can learner control accomodate individual differences, such as different degrees of prior understanding, more effectively than program control (computer-directed learning)? Although learner control seems to be able to adapt to individual differences, research dealing with the variable of learner control has failed to demonstate that learners can make and carry out good decisions (Atkinson, 1972; DiVesta, 1975). Learner control cannot be expected to overcome the persistent fact that "individual characteristics not under control of the individual will determine to a significant extent what and how much that individual will learn in a given instructional setting" (Snow, 1980, p.1). An approach called aptitude-treatment interaction (ATI) proposes that individual differences be met by different approaches to instruction for students of different aptitude. The purpose of an ATI design is to investigate whether a given treatment and attribute interact such that the effect of the treatment depends upon the aptitude of the individual (Cronbach & Snow, 1977).

A number of ATI studies do not involve general aptitudes and abilities, but are concerned with the student's prior familiarity with the subject matter (Cronbach & Snow, 1977). A general hypothesis, based on CAI research, is that the higher the level of prior familiarity, the lower the program support needed to accomplish the objectives (Cronbach & Snow, 1977; Ross, 1984; Tennyson & Buttrey, 1979; Tobias, 1982). Conversely, as the level of prior familiarity decreases, the amount of instructional or program support required increases.

HYPOTHESES

The major focus of this study was to examine relationships between prior conceptual understanding and learner control, treatment effects on outcomes, and Aptitude Treatment Interactions (ATI) effects on outcomes. The general hypothesis asserted that subjects who have some prior conceptual understanding of a particular topic would learn best under conditions of some choice, and subjects with lower prior conceptual understanding of a particular topic will learn best when given some structure. Specific ATI hypotheses were:

H1) Subjects who have a high conceptual understanding of material will have higher mean outcome scores in the Learner Control condition than subjects with low prior conceptual understanding.

H2) There will be no significant difference in mean outcome scores between subjects with high and low prior conceptual understanding in the Program Control condition.

H3) Subjects with low prior conceptual understanding of material will have lower outcome scores in the Learner Control condition than in the Program Control condition.

H4) Subjects with high prior conceptual understanding of material will have no significant difference in mean outcome scores in the two conditions.

No specific hypotheses were formulated concerning time on task because:

a) The literature on time on task in computer-assisted learning studies was confusing. Sometimes significant time savings were indicated in previous studies if learners had control over sequence, pace and amount of instruction, sometimes more time was needed or no significant time savings were indicated.

b) The results of the pilot test conducted for this particular study did not indicate any particular trend or direction in relation to time on task.

METHOD

Subjects and Design

Students from Introductory Biology 103 at Cornell University were selected to participate in the study. A 23- item pretest was administered to 156 volunteer subjects. Based on the pretest scores, 80 subjects were randomly selected as follows: 40 from the low prior conceptual understanding (LPCU) group (raw scores between three and eight) and 40 from the high prior conceptual understanding group (raw pretest scores between eleven and seventeen). These subjects were assigned to one of the two treatment groups using systematic randomization to obtain equal numbers in each treatment condition (Kachigan, 1982).

The study used a 2 (program control vs. learner control) X 2 (low conceptual understanding vs. high conceptual understanding) factorial design. Two groups received instruction through the Program Control condition and two groups received instruction through the Learner Control condition. The dependent variables were posttest scrores and time on task.

Learning Program

Students were alloted two-hour time period in which to study four modules on DNA structure and the transcription and translation phases of protein synthesis. Two versions of accessing the computer-video materials were employed to manipulate control, mode of presentation, and sequence:

1) In the Program Control condition, material was sequenced logically by ordering the computer text, graphics, video and audio segments to reflect the hierarchical nature of the topic structure. Subjects had to complete the learning task in a specified order (Gagne, 1977). An individual's progress was automatically diagnosed by the computer, and remediation and feedback were provided as needed. Students were allowed to control only the pace of the lessons.

2) In the Learner Control condition, students were allowed to control not only the pace of the lesson, but also the sequencing, presentation mode (video, audio, graphics, text), amount of practice, and depth of study. Students could select the order of lessons and modules to be learned, the number of examples and practice items, and could elect to receive remediation or review.

The dependent measures were performance on a criterion test administered on line after the treatment and total time on task as recorded by the computer. A pretreatment questionnaire was administered to gather information on student aptitudes, sex, prior years of biology courses, year, and prior computer experience. Post-treatment information was also collected on selected affective and motivational variables.

Variables

Data were collected on three major classes of variables: 1) dependent variables; 2) independent variables; and 3) process variables.

1. Dependent Variables

A. Posttest. The primary dependent variable was the score on a 20 item multiple choice and short answer examination administered on-line at the end of the treatment (Cronbach alpha = .79). Questions used on the posttest were developed and extensively field tested by McFadden (1980) and Bunderson (1981).

B. Time on task. The length of time (in minutes) from the start of the orientation module until the student completed the final examination was recorded by the computer and used to indicate the total time spent by the student in the treatment. This score was used to assess the overall efficiency of different learners in the two conditions.

2. Independent Measures

While the variables of posttest scores and time to completion are sufficiently specific and meet the measurement requirements of this experiment, the presumed

affective effects of learner control have been ill-defined and measured (Judd et al., 1974). Based on the literature, the following variables would appear to be important correlational variables in relation to learner control.

A. Pretest. Pretest was defined as the total score on a 23 item pretest which was developed to assess students' prior conceptual understanding of the topic of protein synthesis (Cronbach alpha = .73). The format of this examination was similar to the format of the posttest. Some of the questions were duplicated on the posttest. Results of this test were used to divide students into low and high prior conceptual understanding groups.

B. Demographics. Information was collected on learners' demographic characteristics, including age, sex, class, major subject area, years of previous biology courses, and previous microcomputer experience. This information was used to test for the possible confounding effects of these variables.

C. Scholastic aptitude. The ability of individuals to develop skills or acquire knowledge was defined by standardized math and verbal SAT scores.

D. Achievement via Independence. A measure was taken to assess the degree to which learners are able to function autonomously, that is free from external guidance or control. The personality characteristics of the high scorer on the Achievement via Independence (high independence) test appear to be congruent with those which have been characteristic of subjects who benefit more from learner control: maturity (Grubb, 1967) and inquisitiveness (Fry, 1972; Judd, 1972). In this experiment, the Ai instrument measured the possible effects of a disposition to achieve independently on outcome scores. The reliability coefficient, as reported in the CPI manual, is .82.

E. Motivation. Motivation was defined as a general measure of affective tone, the student's perception of the degree to which he or she is generally aroused by the

task, general feelings toward the task, and feelings of personal worth while working on the task (Scott, 1967). To provide an overall score for motivation, a 15- item measure, developed by Scott (1967), was used (Cronbach alpha = .87). The items were scored on a 7-point semantic differential scale.

F. Perceived Control. Perceived control was defined as students' perceptions of the amount of control or regulation they have over sequence, pace, remediation, and amount of practice in either condition. Subjects may think they are in control even when they are not, or they may not think they are in control when they are in fact are. Since these perceptions of control may influence behavior and affect outcome scores, a five item instrument was developed to measure subjects' perceptions of control in the two conditions. Responses were scored on a five-point Likert scale anchored by "1" as strongly agree and "5" as strongly disagree.

Process Variable

Recording of amount of information received. The total number of text pages, video segments, graphics, and practice items examined during the treatment was used to indicate the amount of information received. The computer was programmed to record an individual's progress, choices of media presentation, remediation, and learning strategies.

RESULTS

Several different types of data analysis were conducted. First, descriptive statistics for all variables were calculated. Second, analysis of variance (ANOVA) was used to test the effects of the interactional hypotheses of the study on outcome scores. A parallel analysis was also conducted on time. A Duncan test was conducted to determine differences between cell means. Finally, a multiple regression analysis was conducted investigating the relationships of the other independent variables with posttest performance and time on task.

Descriptive statistics

Table 1 lists the means and standard deviations for the total sample and sample means and standard deviations for high (HPCU) and low (LPCU) prior conceptual understanding subjects in the Program Control and Learner Control conditions. The characteristics of the total sample were as follows: 1) 39 males and 41 females participated in the experiment; 2) 60 percent of the students in the study were biology majors with an average of 1.5 years of biology courses; 3) 70 percent of the students rated their skills using microcomputers as very low or felt that they were not at all skilled. Approximately 20 percent of the students felt that they were moderately skilled using microcomputers and only 5 percent felt that they were very skilled.

INSERT TABLE 1 ABOUT HERE

Regarding verbal and math SAT scores, in measuring these variables, subjects were asked to check one of four categories: 1 = low (490 or lower); 2 = average (491-565); 3 =

moderately high (566-630); and 4 = high (631 or higher). The aptitude means and standard deviations for the high and low groups indicated that most subjects in this study obtained moderately high verbal (566-630) and moderately high to high math (566 or higher) SAT scores. Overall math scores were higher than verbal scores. Since the purpose of this experiment was to assess the interaction of prior conceptual understanding and treatment, it was important that the groups have similar scholastic aptitude scores. The scores indicated that the groups were approximately equal.

To summarize, the descriptive data indicated that the students who participated in this study had a) relatively high scholastic aptitude, b) the ability to achieve independently, and c) high motivation. These results were expected since most of the students selected to participate in the study were selected from a competitve introductory course designed for science majors.

Correlations

Table 2 presents the intercorrelations among the variables. These results were reviewed to obtain an overview of the relationships and differences in the data set. Time and amount of information received were moderately correlated. This is not surprising since the number of examples and amount of information received during the treatment would lengthen the amount of time on task. Pretest and posttest scores are also moderately correlated, which indicated that students who did well on the pretest tended to also do well on the posttest, and students who did poorly on the pretest did poorly on the posttest. Finally, Achievement via Independence and motivation were negatively correlated. Motivation was defined as a general measure of affective tone, the general feelings toward the task, and feelings of personal worth while working on the task. It seems that if students were more independent (as determined by the Ai measure), that they did not feel as positive about the task as students who

were less independent. A speculative explanation of this correlation is that more independent learners may feel constrained by certain CAI tasks. More research is needed before any conclusions can be reached. Another interesting affective outcome was the perceived control score, which indicated students' perceptions of the amount of control or regulation they perceived they had over their own learning. This score was highly correlated with motivation, indicating that subjects who were more motivated generally felt better about the learning task and their own performance if they perceived that they had control. This supports the tentative conclusion that independent subjects generally are more motivated and positive about the learning task if they feel that they are in control of their own learning (Judd et al., 1974).

INSERT TABLE 2 ABOUT HERE

ANOVA

In a 2 X 2 ANOVA on these posttest scores, both main effects, as well as the interaction, were found to be statistically significant (Table 3). Regarding the main effect for treatment, students in the Program Control condition had significantly higher posttest scores than students in the Learner Control condition. Regarding the main effect for prior conceptual understanding, high students significantly outperformed low students on the posttest. Finally, there was a significant interaction effect between treatment and prior conceptual understanding.

INSERT TABLE 3 HERE

The ANOVA test indicated that there were significant differences between means. In order to determine which means differed from which other means, a means separation test (Duncan's method) was conducted. The results of this test showed that the mean posttest score of LPCU students in the Learner Control condition was significantly different from mean posttest scores of students in each of the other three cells. There were no significant differences in mean posttest scores between high prior conceptual understanding students in the Program Control and Learner Control conditions and students with low prior conceptual understanding in the Program Control condition (Figure 1).

INSERT FIGURE 1 HERE

An interaction between instructional treatment (amount of control) and aptitude

(prior conceptual understanding) occurred. All ATI hypotheses were supported:

H 1: Subjects who had high prior conceptual understanding of the topic had higher mean outcome scores in the Learner Control condition than subjects with low prior conceptual understanding. Students with lower pretest scores did most poorly under the Learner Control condition.

H 2: There was no significant difference in mean outcome scores between subjects with high and low prior conceptual understanding in the Program Control condition.

H 3: Subjects with low prior conceptual understanding of material had lower outcome scores in the Learner Control condition than in the Program Control condition.

H 4: Subjects with high prior conceptual understanding of material showed no significant difference in mean outcome scores between conditions. High prior conceptual understanding subjects had slightly higher mean outcome scores in the Program Control condition than in the Learner Control condition.

In conclusion, the outcome of Program Control and Learner Control treatments (Figure 1) formed an ordinal interaction. Prior conceptual understanding is represented on the x axis and posttest scores on the y axis. The results of the ANOVA tests show that Learner Control yields high achievement for HPCU and low achievement for LPCU students. Program Control yields high achievement for both LPCU and HPCU students. This may suggest that all students should be assigned to the Program Control condition since it uniformly results in higher achievement. However, other variables, such as time on task, have to be taken into account before any conclusions can be drawn. Time on task will be discussed in the following section.

Time on task

An important finding that was expected was that HPCU subjects were significantly faster learners than the LPCU subjects. HPCU learners took less time than LPCU learners under both conditions, although a significant main effect for treatment was

not found. Finally, there was a significant interaction effect between treatment and prior conceptual understanding on time on task (Table 4).

INSERT TABLE 4 HERE

The results of a Duncan test on the data showed that LPCU students were not very efficient in their use of time in the Learner Control condition. HPCU students required significantly less time to complete the learning tasks in the Learner Control condition than in the Program Control condition. LPCU subjects did not show any significant difference in time on task between conditions. There was no significant difference between HPCU and LPCU subjects' use of time in the Program Control condition. On the other hand, HPCU students were significantly faster learners than LPCU students in the Learner Control condition (Figure 2).

INSERT FIGURE 2 HERE

As with the posttest scores, the results point toward an advantage in favor of Program Control over Learner Control for students with low prior conceptual understanding. LPCU subjects do not seem to use the options efficiently and effectively in the Learner Control Condition. On the other hand, there was a significant time savings for students with high prior conceptual understanding in the Learner Control Condition.

Multiple Linear Regression

Selected demographic, affective, and aptitude scores of the groups were subjected to multiple stepwise regression analysis on posttest scores. The objectives of this analysis were to assess the relative importance of the various predictor variables in their contribution to variation in the criterion variable and to account for more of the variance of the dependent variable.

The results of the principle regression analysis for posttest as a dependent variable are shown in Table 7 . The F test was the standard one, comparing the size of the R^2 change against the total R^2 and using the corresponding degrees of freedom.

Across all outcomes, the aptitude for independent achievement (Ai scores), scholastic aptitude (SAT scores), and sex (Steps 1 and 2) did not have an appreciable affect on outcome scores and only accounted for 9% of the total variance. The results of Step 3 were significant, indicating that prior experience affected outcome scores. Years of biology, major subject area, and prior computer experience accounted for more than 12% of the variance. It could be argued that part of the variance accounted for in Step 3 directly relates to the major hypotheses of this study, since coursework and experience have something to do with an individual's cognitive structure and understanding of a particular subject area.

The main effects remained significant even after including all other variables in the previous steps, which further verified the results of the ANOVA test. With all other variables controlled, the main effect of pretest accounted for 10% of the variance ($F = 4.18$, $p < .0008$). The main effect of treatment yielded an F of 3.44 ($p < .001$) and accounted for 9 % of the variance. With all other variables entered, the ATI effects accounted for approximately 2.5 % of the variance ($F = 3.317$, $p < .094$). Even though significant interaction differences did not exist beyond what was attributable to the variables entered in the other steps, it could be concluded that the difference in posttest scores

could not be explained by just demographic and affective variables (R^2 = .22) but was also attributable to the experimental manipulation (R^2 = 21.5).

INSERT TABLE 5 ABOUT HERE

The results of the regression analysis for time on task as a dependent variable are shown in Table 6. The results of the variables entered in Step 1 had a significant effect on time on task and accounted for 12 percent of the total variance. Higher verbal aptitude, as measured by SAT scores, accounted for a significant amount of the variance ($p<.03$). With all other variables controlled, the main effect of pretest accounted for 9 percent of the variance. HPCU subjects were significantly faster learners than LPCU subjects. No significant differences on time on task between treatments was found. Finally, no significant interaction differences existed beyond what was attributable to the variables entered in the other steps.

INSERT TABLE 6 ABOUT HERE

DISCUSSION

As expected, subjects with high prior conceptual understanding in the subject area made better use of control options (sequencing of material, review, remediation, depth of study, and amount of practice) and their time than did subjects with low prior conceptual understanding in the Learner Control condition. In the Program Control condition, there were no significant posttest score differences, but there were significant time on task differences between LPCU and HPCU subjects. LPCU subjects had significantly higher posttest scores in the Program Control condition than in the Learner Control condition. However, there were no significant differences in time on task between conditions. Finally, HPCU subjects performed equally as well on the posttest in both Program Control and Learner Control conditions, but they were much more efficient in their use of time in the Learner Control condition.

The results imply that practical teaching efforts should pay careful attention to the organization as well as the content of the knowledge imparted to students, since the organization may markedly affect the students' performance. It seems that students' prior conceptual understanding of a particular subject area is probably of major importance in helping them extract the underlying organization and meaning of information presented (Eylon & Reif, 1984). The achievement differences between HPCU and LPCU subjects on the posttest are consistent with Ausubel's theory of meaningful learning (Ausubel, 1968). Ausubel proposed that assimilation accounted for learning and forgetting and that retention was a direct effect of initial learning. He felt that the most important factor for learning is the prior presence of clear, stable, relevant ideas to act as anchors for the new material. Therefore, it could be proposed that the prior conceptual structure of the students may have acted as their advance organizer, providing the necessary anchors which would allow the material to be incorporated

more completely into the learner's cognitive structure. The hierarchy, thus, does not exist independently of a person's familiarity with a particular domain but instead is dependent upon the person's experience or prior understanding of a particular area.

The presentation of a hierarchical learning sequence seems to increase performance, at least for students with low prior understanding of a topic studying a scientific topic. If the learner is familiar with the content, sequence appears to be considerably less important. Thus, the presentation of well structured hierarchical materials was not as essential for high pretest subjects as for low pretest subjects. Similar results were obtained in other studies (Eylon and Reif, 1984; Meyer, Brandt, & Bluth, 1980).

The results of this experiment also showed that not all students were capable of making appropriate decisions. Overall, subjects performed better in the Program Control condition than in the Learner Control condition. Upon examining the computer records of strategies used by subjects during the experiment, it seemed that LPCU subjects tended to practice too little and to emphasize the areas with which they already had some familiarity. They avoided unfamiliar or difficult topics. It seemed that LPCU subjects had difficulty determining how much practice they needed in order to learn a particular topic. LPCU subjects tended to disregard review and remediation options, repeated and overlearned topics they already understood, and skipped instructional segments which they should have emphasized. In summary, LPCU subjects did not use good learning strategies and made poor sequencing decisions under the Learner Control condition. On the other hand, HPCU subjects were able to function equally well under both conditions. Similar to Tennyson's (1980) findings, analyses revealed that HPCU subjects selected fewer examples and took significantly less time under the Learner Control condition than LPCU subjects. HPCU subjects emphasized topics they did not understand, used practice questions to discover areas of weaknesses, chose remediation

and review segments, and were able to efficiently and effectively organize their learning strategies. If subjects had a moderate to high prior conceptual understanding of a particular topic, they were more likely to study areas that they did not understand and take advantage of the options available to them in the Learner Control condition.

The results point toward an advantage in favor of Program Control over Learner Control for students with low prior conceptual understanding of a topic. Learners can be given more control if their prior conceptual understanding of a topic is relatively high; conversely, learners should be provided with more structure if their prior conceptual understanding of a topic is low. These results provided strong experimental evidence for positions taken by Tobias (1982) and Tennyson (1980) which claimed that there is an interaction between learner control of instruction and the subjects' prior familiarity with the material to be learned. The research results also suggest that efforts continue to be made to develop and test models for learning systems which have the capability to adapt to individual learner's needs.

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TABLE 1

Means and Standard Deviations for Total Sample, High and Low Prior Conceptual Understanding Subjects in the Learner and Program Control Conditions

	Total Sample		High Learners		Low Learners		Learner Control		Program Control	
	N=80		N=40		N=40		N=40		N=40	
Variable	Means	S.D.	Means	S.D.	Means	S.D	Means	S.D.	Means	S.D
1. Verbal SAT (categorized)	3.00	.85	3.02	.83	3.00	.88	3.05	.87	2.90	.84
2. Math SAT (categorized)	3.52	.61	3.50	.64	3.57	.59	3.60	.54	3.45	.67
3. AI	21.22	3.44	21.60	3.31	20.85	3.57	21.52	3.12	20.92	3.75
4. Motivation	85.60	11.24	87.37	10.90	83.82	11.38	84.10	11.74	87.10	10.65
5. Perceived Control	1.87	.69	1.84	.59	1.91	.78	1.82	.71	1.93	.66
6. Pretest	10.33	4.19	13.90	2.60	6.77	1.59	10.60	4.58	10.07	3.79
7. Information Received	54.56	9.32	53.15	10.11	55.97	8.30	49.15	10.75	59.97	.80
8. Posttest	16.82	2.38	17.92	1.28	15.80	2.74	16.10	2.83	17.62	1.49
9. Time	67.20	10.33	63.75	8.06	70.65	11.26	65.30	11.24	69.10	9.08

Table 2
Correlation Coefficients for the Total Sample

Variable	1	2	3	4	5	6	7	8
1. Posttest	---							
2. Pretest	.39**							
3. Time	-.10	-.39**						
4. Verbal	.17	.14	-.24*					
5. Math	.15	.07	-.15	.33**				
6. Information	.04	-.28**	.51**	-.14	-.07			
7. Ai	.17	.12	-.06	.33*	.08	.00		
8. Motivation	.16	.13	-.01	.00	-.03	-.04	-.22*	
9. Perceived Control	.11	.04	-.07	.16	.12	-.05	.16	-.49**

*$p < .05$

**$p < .01$

Table 3
ANOVA Table for Post-test Scores

Source	SS	df	MS	F	p
MAIN EFFECTS					
Condition	46.31	1	46.31	12.96	0.0006
Pretest	90.31	1	90.31	25.16	0.0001
INTERACTION (Treatment X Pretest)	37.81	1	37.81	10.53	0.0017
RESIDUAL	272.85	76	3.59		

Table 4

ANOVA Table for Time on Task

Source	SS	df	MS	F	p
MAIN EFFECTS					
Condition	288.8	1	288.80	2.77	.1003
Pretest	952.2	1	9.93	25.16	.0023
INTERACTION (Treatment X Pretest)	1280.2	1	37.81	10.53	.0017
RESIDUAL	7152.6	76	94.11		

Table 5
Results of Multiple Stepwise Regression Analysis for Posttest as a Dependent Variable

Variable	R Square	R Square Change	F Change	Significance Change
Step 1				
Math, Verbal, Sex	.0747	.0747	2.018	.119
Step 2				
Achievement via Ind.	.0956	.0210	1.715	.194
Step 3				
Biology, Major, Comp.	.2220	.1263	3.842	.013
Step 4				
Pretest (H vs. L)	.3235	.1015	10.506	.002
Step 5				
Treatment (PC vs. LC)	.4150	.0915	10.795	.002
Step 6				
Pretest X Treatment	.4388	.0238	2.884	.094

Table 6
Results of Multiple Stepwise Regression Analysis
for Time as a Dependent Variable

Variable	R Square	R Square Change	F Change	Significance Change
Step 1				
Math, Verbal, Sex	.1284	.1284	3.684	.016
Step 2				
Achievement via Ind.	.1284	.0000	.000	.994
Step 3				
Biology, Major, Comp.	.1649	.0365	1.034	.383
Step 4				
Pretest (H vs. L)	.2603	.0954	9.024	.004
Step 5				
Treatment (PC vs. LC)	.2716	.0113	1.071	.304
Step 6				
Pretest * Treatment	.2728	.0012	.115	.736

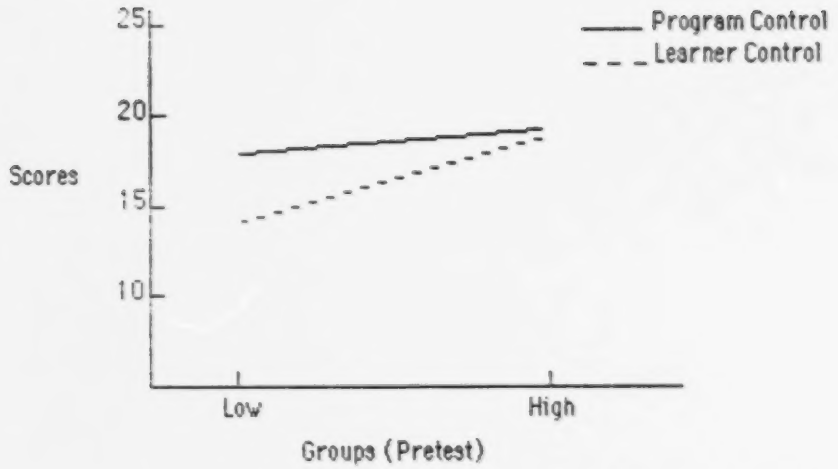

Figure 1. Mean posttest scores attained in the Program and Learner Control Conditions for high and low prior conceptual understanding groups.

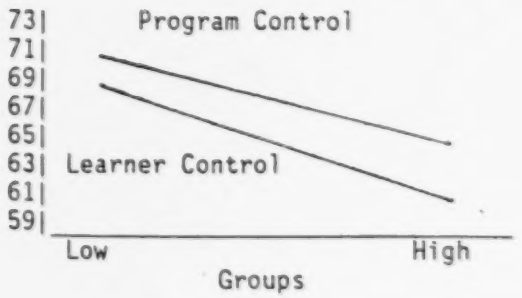

Figure 2: Time on Task for Groups between Conditions